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Biological and Systematic Studies
on the Bombidae of Illinois

Entomology

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ON THE
BOMBIDAE OF ILLINOIS

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WARREN WILLIAMSON
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THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE

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IN

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I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Warren Williamson

ENTITLED Biological and Systematic Studies on the Bombidae of
Illinois

BE ACCEPTED AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE

DEGREE OF Master of Arts in Entomology.

J. W. Folsom

In Charge of Major Work

Stephen A. Forbes

Head of Department

Recommendation concurred in:

Committee

on

Final Examination

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BIOLOGICAL AND SYSTEMATIC STUDIES ON
THE BOMBIDAE OF ILLINOIS.

During the summer and autumn of 1910 the writer made some collections and observations in order to get first hand information concerning the bumblebees found in the vicinity of Champaign and Urbana, Illinois. The following winter was spent in working over the notes made and material collected, studying the literature, and examining specimens in the collections of the University of Illinois and the State Laboratory of Natural History. Experiments in keeping hibernating queens and rearing parasites were also undertaken. Further observations were made during the spring of 1911 on the habits of over-wintered queens. Facts regarding their food and methods of founding colonies were noted.

Special acknowledgment must be made to Dr. J. W. Folsom, assistant professor of entomology, for valuable aid and helpful suggestions freely given at all times.

I. BIOLOGICAL.

Methods.

The methods of investigation varied according to the season and the kind of information desired. Early in the season of 1911 much time was spent in the field looking for queens that had survived the winter and were getting ready to start colonies. Several of these were captured and kept in order to see if they would oviposit in captivity. Others which had already oviposited were taken with their nests and eggs and kept under observation.

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Later, as soon as the first workers could be found out-of-doors, the nest was looked for, and when found the entire colony was taken alive and placed in an observation box.

The method of making an observation box is simple. The lid is removed from an ordinary cigar box. Across the top of the box are nailed parallel strips of tin which have been previously doubled and bent longitudinally so as to form a capital T when seen in cross-section. They resemble the T-tins used by bee-keepers. They should be about one inch apart. Small rectangular pieces of glass are laid on between the strips. This gives a good view of the interior of the box as well as an opportunity to reach with forceps any part of the nest without disturbing the entire colony. A $5/8$ -inch hole is bored near the bottom of the box at each end. One hole is covered with a wire screen to allow ventilation. The opposite hole may be closed with a cork which can be removed when desired.

When taking a colony on a clear day it was found best to wait until about sunset when most of the bees were in the nest. If the weather was wet and cloudy, the capture could be made at once. For quieting the bees, sulphuric ether proved to be safer than chloroform, the latter being more apt to be fatal to the larvæ.

The location of the nest usually determined the details of taking a colony. If it was in a gopher burrow, the ether was poured into the entrance and a garden trowel used to dig out the stupified bees. A stout wire previously thrust into the hole served as a guide in digging. If the nest was on the surface of the ground, the ether was poured on it and then it was

covered by a bell jar to confine the fumes until the bees became quiet. In either case the nest and comb were obtained as nearly intact as possible. The nest and revived bees were placed in the box which was kept closed for a day or two. The box was then fitted under a window sash, or as in two instances, against a greenhouse wall where a small hole had been cut through the glass side. When the bees were not being observed the box was covered with a piece of black cloth. An alighting-board was fitted just outside the entrance, and on this a little honey was provided for the first day or two after the bees were let out-of-doors.

The various activities of the bees in the nest and the arrival and departure of foragers could be observed without much difficulty. In order to get certain data it was sometimes necessary to mark individual bees. This was done by catching the bee in a net and wetting it with red ink. This treatment did not seem to have any bad effect on the bee, although the stain was conspicuous for several days.

Collections and observations were made at various times during the summer and early autumn. Visits were made to red clover fields while in bloom and from actual counts made on limited areas, estimates were made of the efficiency of the bumblebees in pollination.

Several nests were examined in the field without taking the colonies. These were all in slight depressions of the surface of the ground in deserted mouse nests. By covering the nest with a pane of glass the action of the bees could be observed. The bees were quieted with ether whenever it was desirable to count them or to examine the comb.

SUMMARY OF LIFE HISTORY

Bumblebees are social, living together in colonies of a score or more individuals representing three different castes, males, queens, and workers. None survive the winter except the queens, which live through that season in a dormant condition. These live but one year.

A colony is founded in the spring by an overwintered queen. After reviving from the dormant state, she feeds on the spring flowers and looks for a nesting site. After a suitable place has been found, usually a deserted field-mouse nest or a gopher burrow, the bee collects and brings to it a small quantity of pollen and wax in which the first eggs are laid. A cell is also made of the same material and filled with honey.

The eggs, numbering about a dozen, are all laid in the same cavity, but when they hatch, the young larvae separate, each making a cell in the mass of pollen and wax which is gradually augmented by the queen. When full-grown, the larva spins a silken cocoon from which the adult subsequently escapes by gnawing around the upper end so as to form a lid. Some of the empty cocoons are utilized as receptacles for storing nectar and pollen.

All of the first bees to emerge are workers which relieve the queen from the work of collecting food and caring for the young. Before these have emerged the queen has laid other eggs. Oviposition is repeated at frequent intervals, so that a colony examined at any time during the summer will be found to contain bees in all stages of development.

During the latter part of summer, males and queens are produced. The former fertilize the latter and perish when the weather becomes cold. The old queen and the workers also die, but the young queens crawl into sheltered places where they hibernate.

HIBERNATION OF QUEENS.

NATURAL HIBERNATION:--When the first chilly days in autumn have come the young queens seek their winter quarters. Any situation that affords sufficient protection from the weather and predaceous enemies is suitable. They have been found in crevices in logs and stumps and in the ground. Putnam records the finding of a dormant queen under leaves, while the snow was on the ground. (Proc. Essex Inst. IV, 104.) The writer made frequent searches during the autumn and early winter of 1910 but was unable to find any Bombus queens, altho numerous Psithyrus females were taken. Scores of old nests were examined without result, indicating that rarely, if ever, a queen passes the winter in an old nest.

ARTIFICIAL HIBERNATION:--On Sept. 10, 1910 the writer began the first of a series of experiments in keeping hibernating queens. A queen Bombus fervidus was taken alive and placed in a box where it was kept supplied with honey and water and red clover blossoms as long as they were obtainable. This experiment was conducted in a building which is not heated during the winter. No observations of temperature were made until the bee became sluggish. This was on Oct. 28, when a thermometer held in the box registered 11 degrees Fahrenheit. The box was then partly filled with dead grass and in it were also placed self-registering maximum and minimum Fahrenheit thermometers which were examined every two or three days. The bee was first seen to be dormant on Dec. 1. The lowest recorded temperature up to that time was

20 degrees above zero. The temperature records by months are as follows:

	Dec.	Jan.	Feb.	March
Maximum degrees Fahr.	55	45	60	70
Minimum " "	10	2	14	15
Average " "	32.5	23.5	37	42.5

During most of this time the bee remained torpid but relaxed. On March 15 there was first noticed a fading of the pigment of the eyes, a condition that the writer has never seen in a living bee. A dissection made April 6 showed the viscera considerably dessicated. Life had evidently been extinct for some time.

Another queen of the same species was taken out-of-doors Oct. 1, 1910 and kept under similar conditions with the exception that a little water or snow was sprinkled in the box every week or two. The first observation of temperature was made Nov. 5. A thermometer in the box registered 18 degrees +. The bee was not yet dormant and did not become so until Dec. 1. The temperature records by months are as follows:

	Dec.	Jan.	Feb.	March
Maximum degrees Fahr.	54	46	59	69
Minimum " "	11	3	14	16
Average " "	32.5	24.5	36.5	42.5

The bee was alive on April 1, as shown by its movements; it was then removed and placed with several Psithyrus females in a box containing moist sand. It was dead on April 10 and covered with mold.

As stated before, no Bombus queens were found in hibernation, altho a number of Psithyrus females were found in their winter quarters. Notes were made on these because of their resemblance to Bombus in structure and habits.

Seven Psithyrus females were found not yet dormant in their winter quarters Oct. 25, 1910. They were in loose, moderately dry, soft loam at the base of an uprooted tree in woods. Each was in an individual cell about four inches under ground. They were placed in a box containing leaves and grass and transferred to the same building where the Bombus queens were kept. They were active until Oct. 28, when they became sluggish from cold. They were seen to be dormant on Dec. 1. On account of an insufficient supply of self-registering thermometers a complete temperature record was not obtained. The observations that were made, however, indicate that very nearly the same conditions of temperature must have existed as were found in the boxes containing the Bombus queens. Two of the bees were living but still dormant on April 1. As it was supposed that the death of the others was due to dryness, the survivors were placed with several others in a box containing moist sand and dried grass. They were dead on April 10 and ~~was~~ covered with mold.

On Oct. 26, 1910 a female Psithyrus was taken from its hibernating quarters in a cavity in a decayed log in woods. It was about ten inches beneath the surface of the log. The wood surrounding it was moist. This bee was kept all winter in a box containing moist earth and leaves in an old unheated greenhouse. The average monthly temperature records for the winter are as follows:

Months	Dec.	Jan.	Feb.	March
Average degrees Fahr.	30	25	36	42

The bee was dormant on Dec. 1. It showed signs of life on April 14 by moving its legs. On April 20 it was dead and covered with mold.

Temperature records were kept of another box containing two Psithyrus females taken Nov. 4, 1910. Both were found in cavities in decayed stumps about one foot inside the surface. Their surroundings were moist. They were kept all winter in a box of leaves, grass, and earth which was moistened every week or two.

They survived until April 1 under the following conditions of temperature:

	Dec.	Jan.	Feb.	March
Maximum degrees Fahr.	53	45	60	68
Minimum " "	10	2	15	15
Average " "	36.5	23.5	37.5	42.5

They were dead on April 10 and covered with mold.

The last experiment in keeping Psithyrus females found in their hibernating quarters was begun Nov. 10, 1910, with three individuals taken on that date from cavities in a decayed stump. They were placed in a box containing dried grass and leaves. The record of temperature for this experiment is not complete because of the lack of self-registering thermometers, but enough observations were made to indicate that the range of temperature did not differ much from that of the other experiments. The bees were all dead on April 1.

SUMMARY OF RESULTS:--Two Bombus and thirteen Psithyrus

females were used in the experiments, fifteen individuals in all, occupying six different boxes. The conditions of temperature in all the boxes were nearly the same. Eleven bees were kept under dry conditions, and of these one was dead by March 15 and only two survived until April 1. The four bees occupying boxes in which the nest material was kept moist were all living April 1.

Their death within two weeks afterward was probably not due to cold weather. The records show that the minimum temperature between April 1 and April 15 was 40 degrees Fahrenheit in the building where the experiments were conducted.

HABITS OF QUEENS IN SPRING

FEEDING:--I have never found any queens out-of-doors until the wild flowers have appeared. The first seen by me in 1911 were two individuals of Bombus ridingsii visiting the flowers of Dicentra in dense woods. This was on April 24, though doubtless queens could have been seen a few days earlier. Eight others were seen during the month of April feeding on the flowers of Dicentra, Trillium and gooseberry. Three B. pennsylvanicus queens were observed during the same period visiting the flowers of Trillium recurvatum. On May 5 a visit was made to a large apple orchard when the trees were in full bloom. Many bumblebees were feeding on the blossoms. It was estimated that ninety percent of them belonged to two species, B. pennsylvanicus and B. americanorum. They resemble each other so closely that it is impossible to distinguish them unless they are examined at close range. The other species recognized in the orchard was B. fervidus.

Observations were made May 7 in a large blue-grass pasture. B. fervidus was abundant, and there were several individuals of B. pennsylvanicus and ridingsii. Many were feeding on dandelions, which was the only kind of flower in the field. None, however, could be found which had any pollen on their legs. Observations were also made on queen bumblebees visiting the flowers of horse chestnut on May 10. A large tree was selected and observed about an hour. Estimates were made of the relative numbers of different species seen during that time. Seventy-five percent consisted of B. pennsylvanicus and B. americanorum. About twenty

percent were B. ridingsii and B. virginicus whose resemblance makes it impossible to distinguish one from the other in flight. The remainder were B. fervidus.

A B. fervidus queen was taken May 14. It was killed and dissected the next day. The honey sac and intestine were removed. The former was distended with honey. The latter was placed on a microscope slide, and its walls and contents were examined under the microscope. The muscles of the walls were stained yellow. The ilium and particularly the colon were distended with a mass of minute yellow particles which were compared with the pollen grains of dandelion. The two were almost identical. The only apparent difference was the absence of surface spines on most of the grains found in the alimentary tract.

PROSPECTING:--Altho several queens had been previously seen visiting flowers it was not until April 28 that any was seen evidently looking for a nesting place. On that day a B. virginicus was observed for about thirty minutes while it was flying about in open woods. It never rose more than a foot above the ground and frequently alighted to enter holes, or crevices in stumps. It did not remain in one place more than half a minute at most. The course of its explorations was very irregular. At that time there were many flowers blooming in the woods: Claytonia, Dicentra, Mertensia, Ranunculus, Trillium, and Viola. The bee often flew over them but never stopped to feed.

On April 30, and again on May 2, B. ridingsii was found very common in atract of dense woods. Several were seen entering mouse burrows, but no comb was found when the burrows were examined. On May 6 the same locality was visited. More than a dozen B. ridingsii queens were seen entering mouse burrows. No

nests had been started, however.

On May 7 observations were made in a large blue-grass meadow and the following notes were made: B. fervidus abundant. Several ridingsii and B. pennsylvanicus. Some twenty or thirty were seen to enter old gopher burrows and nests of field mice. In two of the latter the queen buzzed when the nest was stirred, and at length came out. The cavity of the nest was nicely shaped out and smoothed, but there were no signs of larval food.

While watching bumblebees feeding on the flowers of horse chestnut on May 10 my attention was called to a B. virginicus which flew to the ground and disappeared in a clump of blue-grass. A depression, probably a horse track, was found filled with dead grass and leaves. When this was disturbed the bee buzzed and finally came out. It was evident, from a careful examination of the material, that the bee had not started a nest.

On May 21 scores of queens were seen feeding on red clover blossoms. The species recognized were B. fervidus, B. americanorum, and B. pennsylvanicus.

NEST-BUILDING.

The favorite nesting site in this locality seems to be an abandoned gopher burrow or a deserted field-mouse nest. Other situations are sometimes selected, such as cavities in logs or spaces in walls of buildings. The cavity that is selected must contain an accumulation of dried grass or light fibrous material which is used in the construction of the nest. The bees are unable to gather sufficient quantities of nest material for themselves, so they must depend upon the previous work of mice or other animals.

According to my observations, the queen, after finding a suitable nesting site, constructs a cell of pollen and wax and fills it with honey. This is about $1\frac{1}{2}$ inch in diameter and is roughly oval. Apparently a quantity of honey is collected before any eggs are laid. This statement is based on observations made on May 14, 1911. A nest of B. fervidus found on that day contained no eggs and a nest of B. americanorum contained but one. Yet the honey cells in both nests were well filled.

About $1\frac{1}{2}$ inch from the honey cell the queen deposits a flake of pollen and wax about $1\frac{1}{2}$ inch in diameter. On this as a foundation she constructs an irregular dome of the same material and nearly a half inch high. The eggs are laid on the floor of the cell thus made. As far as my observations go all the eggs have one end resting near the center of the cell floor.

In a Bombus fervidus queen which was dissected May 15, 1911, the colon was found to be distended with pollen grains while

the mid-intestine was almost empty. None of the queens seen out-of-doors during the time of nest-building had pollen on their legs. There is a possibility that the first larval food is passed through the alimentary canal of the queen.

The egg period was not learned nor was it possible to get data on the development of the larvae because in all cases when a new nest was taken with the queen and kept in an observation box the queen neglected the brood and refused to lay any more eggs. In one case it was suspected that the queen herself destroyed the eggs and larvae.

If a new nest containing only a queen is disturbed, the bee will not leave it to drive the intruder away but makes a peculiar buzzing sound resembling that made by many workers when they are molested. If the nest is torn open the queen will eventually fly away without making any resistance.

COMPOSITION OF THE FOOD MASS.

On May 16 fresh material from the food mass in which eggs were found was examined and submitted to simple tests in order to determine its nature. In small fragments spread thin on microscope slides and examined under the microscope, at least one half of the bulk was seen to consist of pollen grains of several species, most of them colorless, tho a few had bright yellow contents. Between the pollen grains was a greenish-yellow homogeneous substance. When the mass was heated on a microscope slide, this greenish-yellow substance melted and ran out on the sides leaving a cluster of pollen grains. The substance had the consistency of the wax of the honey-bee, with which it was compared, and when a lump of this and a similar lump of beeswax were placed side by side and heated very gradually, both melted at the same temperature. Furthermore, both substances were soluble in sulphuric ether. Therefore we may use the term wax for this substance, even though the pressure of time in finishing the thesis did not permit us to make further chemical tests. From a large mass of food material only a small amount of wax could be extracted by melting—possibly ten per cent. of the total volume. The microscopical observations mentioned above evidently did not show the actual proportion of wax to pollen—merely the amount of wax about each pollen grain as seen in one plane. I estimate that the volume of the pollen is about eight or nine times that of the wax. In the case of Bombus vagans and terricola, Coville (Proc. Ent. Soc. Wash., Vol. I, p. 199) regarded the presence of

the pollen as incidental. Putnam (Proc. Essex Inst., Vol. IV, p. 101) says the queen "collects a small amount of pollen mixed with honey, and in this deposits from seven to fourteen eggs, gradually adding to the pollen mass until the first brood is hatched". In the specimens that I examined I found nothing but pollen and wax.

SUMMER HISTORY OF THE COLONY

NESTS :--The summer history of the colony may be said to begin with the appearance of the workers out of doors. These may be found in a field of red clover in bloom. The nest is usually in the same field or not far away. It may be found by making a careful search of the locality and noting any particular spot where the bees are coming and going. After the workers have become numerous the nests are easy enough to find.

The first nest examined in 1910 was found July 16 in a gopher burrow in a blue-grass meadow. It was about eighteen inches from the entrance of the burrow and a foot below the surface of the ground.

The nest material consisted of about a handful of dried blue-grass leaves mixed with a few fine roots of the same plant. This entirely surrounded the comb.

The species was B. fervidus. The bees that were seen were one queen, seventeen workers, and six larvæ; these were accidentally thrown out of their cells. Probably other larvæ and eggs were in the cells, but these were not opened.

The comb consisted of a mass of wax and pollen, probably containing eggs and young larvæ, and thirty cocoons. Twelve contained brood. Ten were empty. Six others had a little honey in each, and two contained pollen.

This colony was taken and placed in an observation box. By August first the colony numbered about a dozen major workers and the same number of minor workers. There were about fifty

cocoons at that time. Bees had emerged from thirty of these, and ten were being used for storing food. Six contained honey and were almost completely capped over with wax. On Aug. 15 it was estimated that there were about seventy cocoons. At that time the workers began to build a wall of wax on one side of the nest. On the 25th it extended entirely across the box and was five inches long and from one inch to two inches high. In some places it touched the pane of glass covering the box.

While empty cocoons became more numerous with the advance of the season, there was not a corresponding increase in the number of bees that were seen. Doubtless a great many foragers were killed out-of-doors or failed for various other reasons to return to the nest. As the minor workers are not in the habit of leaving the nest, it is very likely that they are unable to find their way back if they chance to wander out. It never occurred to the writer, however, to test this by experiment while there were opportunities to do so.

By Sept. 1 the mass of comb had become so large that it was impossible to make a reasonable estimate of the number of cocoons without greatly disturbing the colony.

The first young queens, three in number, were seen Sept. 9. On the next day the first male was seen. For the next two weeks queens and males were emerging every day or two. Doubtless many left the nest without being observed. Those that were seen to leave did not make a locality study, therefore we may safely assume that they never returned. In all, about fifteen queens and an equal number of males emerged in this colony. Three females of Psithyrus variabilis were seen on the comb Sept. 20. If any males of that species emerged, they escaped observation.

The old queen was last seen alive on Oct. 20, and was not seen at all for more than two weeks afterward when on Nov. 5 she was found dead among the empty cocoons. Five or six minor workers were seen alive up to Nov. 1.

On Dec. 15 the nest was overhauled and the cocoons counted. There were about two hundred and ten, the exact number being impossible to get because of the fragmentary condition of some of them. Six workers and one male were found dead among the cocoons.

Another colony of B. fervidus was taken July 23, 1910 from a mouse nest on the surface of the ground. Unfortunately, the queen could not be found. There were about a dozen workers. The nest and colony were placed in an observation box. The bees began to work on the day following their capture. They were counted on Aug. 1. There were twenty-nine workers, of which seven were foragers. There were twenty-five cells apparently containing brood and twenty cocoons from which the bees had emerged. Ten of these contained honey and three had pollen. The bees had surrounded the comb containing food with dead grass that had been put in the box for them. They neglected the cells containing brood. This colony did not thrive. It dwindled away until on Sept. 1 the box was deserted. Probably the failure was due to the absence of the queen.

A colony of B. americanorum was taken Sept. 19 from a field-mouse nest in a blue-grass pasture. This was kept for a few weeks under observation. The cocoons and wax cells were not counted when the nest was taken. One queen and ten workers were seen. The notes made on this colony are as follows: Sept. 22. The

bees have almost completely covered the comb with a wall of wax and dead grass. A female Psithyrus variabilis was seen to-day. On Sept. 23 four females of Psithyrus were seen. The box was uncorked and the bees allowed to go out of doors on Sept. 25. Two Bombus workers made locality studies before leaving the nest. Ten Psithyrus females left without making locality studies, and probably did not return. Observations made on the 28th and 30th indicated that Psithyrus adults must have emerged every day or two. On Oct. 3 the bees were chloroformed and counted. The cocoons also were examined and counted. Of B. americanorum there were four major and eight minor workers, and one queen. There were eleven males and twenty females of Psithyrus variabilis. There were three young bees in cells, species not determined. One hundred and sixty-two empty cocoons were found. It is evident that this colony was greatly injured by the numerous inquilines which developed in the nest.

A nest of B. pennsylvanicus was examined Sept. 25. This was in a field-mouse nest on the surface of the ground in a blue-grass meadow. The bees found were one queen, seven major workers, fourteen minor workers, seven larvæ in wax cells, and about twenty pupæ, judging from the number of cocoons not yet opened. One male and one female of Psithyrus variabilis were found. No young queens or males of B. pennsylvanicus were seen. The nest contained twenty unopened cocoons, forty-eight cells with a little honey in each and four containing pollen. No other notes were made on this colony.

A nest of B. americanorum was found under plowed sod in a blue-grass field on Oct. 10, 1910. The bees were quieted with ether and counted. The following were left to revive in the nest:

one queen, one major worker and three minor workers of B. americanorum. The following were preserved as specimens: seven males of Psithyrus variabilis, two major workers of B. americanorum, and six larvæ, species undetermined. Seven pupariæ and one larva of a dipterous parasite were taken from the abdomens of eight dead Bombus workers. These were kept for rearing.

The nest was overhauled Oct. 15. Four hundred and ten cells were counted. All were empty except four containing honey, and three containing pollen. No brood was found. Thirty-one males of Psithyrus variabilis were taken in, and just outside the nest, two major workers of B. americanorum in the nest, and one dead male of the same species. On Oct. 18 the nest was examined and twelve males of Psithyrus variabilis were found. Some of these were eating the pollen and honey left in the comb.

HABITS OF THE QUEENS IN SUMMER.

After the first workers have emerged the queen does not collect any more food but leaves that work to them. She continues to deposit eggs, however. After the workers have assumed the duty of collecting food, the queen rarely leaves the nest. She feeds from the common store. The queens that were kept in our observation boxes either remained motionless on the comb or crawled about touching a cell here and there with the antennae or mouth parts.

An old queen does not long survive the cold days of autumn. My observations indicate that as a rule she dies in the nest.

HABITS OF THE MAJOR WORKERS

These are the foragers, the kind most frequently seen out-of-doors. Their duties consist chiefly in collecting food for the colony. The only work that we have observed them doing inside the nest is fanning the comb or performing sentinel duty. These functions will be referred to again in the discussion of the minor workers, to whom such duties particularly belong.

LOCALITY STUDIES:--When a young forager leaves the nest for the first time, or when any forager first leaves a nest after it has been moved, as in the case of a colony in an observation box, it always makes a study of the locality. Usually a short flight is made at first. This may not take the bee more than a yard from the entrance of the nest, to which it returns immediately. Soon afterwards it flies out again and circles about several times gradually getting farther away. It may or may not return to the nest again before starting out on a foraging trip. On its return from the field it circles about a few times, apparently in order to locate the nest. The departure for the second trip is begun with a locality study less extensive than the first. After two or three trips the bee can go and come directly.

As soon as a forager returns from a trip to the field it goes directly to the cocoons and deposits its load. If bringing in nectar, it perches on the edge of a honey pot, inserts its head and forces the nectar from its mouth, assisted by a contraction of the abdomen. If the bee is carrying pollen, it perches on the edge of a pollen pot with its front and middle pairs of legs

head outward, spreads its wings, and then scrapes the pollen from the corbicula by rubbing the hind legs together. Nectar is brought in on every trip, but as a rule several trips will be made without depositing pollen. If both nectar and pollen are brought in, the nectar is always deposited first.

Observations were made on the arrival and departure of foragers in two different colonies, each located about two hundred yards from a field of red clover in full bloom. One was a colony of B. fervidus in which the movements of seven different foragers were observed Aug. 4, 1910. The other colony was B. americanorum observed Aug. 5. Six different foragers were at work during that time. The weather was bright and warm on both days. Each colony was under observation two hours and a half, beginning at 1 p. m. The results do not show any difference in respect to species. Taking the entire number observed, the average time spent away from the nest for each trip was thirty minutes, with two and a half minutes in the nest between trips.

Weather conditions largely influence the activity of the foragers. During wet or cold weather they remain in the nest, but they keep very busy on bright warm days.

HABITS OF THE MINOR WORKERS

The minor workers are apparently of two sizes, at any rate we know this to be the case with three different species: B. fervidus, B. separatus, and B. americanorum. The chief duty of the smaller sized minor workers is feeding the larvæ. For that reason they have been called nurse bees by Coville (Proc. Ent. Soc. Wash., Vol. I, p. 200). My observations on the method of feeding the larvae agree with Covilles' account. A nurse bee draws some honey from a honey pot, then goes to a pollen pot, inserts its head and apparently makes a mixture of pollen and honey. This operation usually requires five or ten minutes. Then the bee goes to one of the larvæ that is lying in its waxen cell and injects a brownish fluid through a hole previously made in the cell wall by another worker. The fluid is taken by the larva.

The larger of the minor workers, which we may call medium-sized workers, perform various duties about the nest. One of them can often be found stationed as a sentinel at the entrance of the nest, although as stated before, a forager will sometimes perform this duty. Several of these medium-sized workers will combine to drive out an intruder. If danger threatens from the outside they will leave the nest to fight. They do all the inside work of the nest except feeding the larvæ. They surround the comb with walls of wax, outside of which they pile up bits of grass and small sticks. When piling up nest material they face away from it and kick back in the manner of a dog digging in the ground. In hot weather they take turns in ventilating the nest,

sometimes, however, being helped by a forager. They station themselves on the comb or at the entrance of the nest and vibrate the wings rapidly. Usually one works alone but occasionally two will work together. Some have been seen to vibrate the wings continuously for one minute, and, when stopping, to resume the operation almost instantly.

As Coville states, the bees are cleanly in their habits. The ~~fd~~eces were always deposited at some distance from the nest in the corner of the observation box. Dead larvae were thrown out of the box by workers.

THE MALES.

The males, or drones, appear in the latter part of summer or early autumn at about the time of the emergence of the young queens. The earliest dates in my records are Sept. 1 for B. americanorum and Sept. 5 for B. fervidus. They contribute nothing to the support of the colony, apparently the sole reason for their existence being to impregnate the queens. Like the drones of honey-bees they have no sting or pollen baskets.

The males have the habit of frequently swarming about the nest, making such a noise with their wings that they can be heard from a distance of several rods. This usually happens when the young queens leave the nest. The males circle about rapidly, darting at each other or at workers leaving or returning to the nest. They are easily excited by any moving object.

Males of B. fervidus have been found alive out-of-doors as late in the season as Sept. 24, and B. americanorum as late as Oct. 15. They feed on the late clover blossoms and on the flowers of thistle, goldenrod and aster. The males of Psithyrus sp. are often found with them.

The union of the sexes does not occur during flight as it does in the case of the honey-bee. Several published accounts record the finding of the sexes in copula. The observers in those instances evidently did not see the beginning of copulation. The writer once observed from beginning to end the mating of the male and female of Bombus fervidus. This occurred Sept. 10, 1910, near a nest in a gopher burrow located in an open blue-grass

meadow on the University farm. My attention was called to the place by the swarming of the drones. A queen was soon discovered on the ground evidently trying to escape from a male which was on her back and holding her with its middle claws clasping the thorax and the hind claws clasping the abdomen. Two other drones were on the ground near by, and when either approached within two inches of the queen she would strike at him with her legs, usually the middle pair. The actions of the drones toward each other were evidently hostile. After a few minutes, the drone that was clasping the queen released its hold on the thorax and slid back over the abdomen. An instant later the pair were in copula, the queen crawling about and dragging the male, which lay on its back. The sting of the queen was extruded above and parallel to the ventral portion of the male's abdomen. The queen crawled about in a space about six inches in diameter, sometimes apparently trying to climb up a grass stem, which, however, would not support the weight of the bees. The pair remained in copula eleven minutes; then the male, voluntarily, apparently, separated from the queen and flew away. The queen remained on the ground where another male soon afterwards approached her but was repelled.

POLLINATION.

Bumblebees are the most effective agents in cross pollinizing red clover. This fact has been conclusively proven by the experiments of Darwin and others.

The method of cross pollination is as follows:

In its attempt to reach the nectar located at the base of the stamens, the bumblebee presses down the keel and wings of the floret. The stigma, being at the end of the long and curved style strikes the lower side of the bees head and receives the pollen brought from another clover floret. Since the stamens are shorter than the pistil they do not touch the bee until after fertilization has been accomplished, so that their pollen is carried away to the next flower.

On July 30, 1910 an estimate was made of the number of bumblebees per acre working at the same time in a moderately thick stand of red clover. This was done by rapidly walking across a small plot several times, each time taking a six foot strip and counting the bees seen on clover heads. No attempt was made to recognize the species. The time was 4 p. m., the weather warm and dry. The count indicated that about forty bumblebees were working at the same time on one acre.

Observations were also made to determine the speed with which the bees worked. This was done in the same field and on the same day, but about one hour earlier. Foragers only were observed. The results are shown by the following table. The dashes in the last column indicate that the bee flew out of range.

Species	Time spent on clover head	No. florets visited	Time in flight to next head
B. americanorum	10 sec.	6	1 sec.
	28 "	19	4 "
	12 "	9	-----
B. americanorum	9 "	15	2 sec.
	25 "	13	-----
B. americanorum	15 "	6	-----
B. americanorum	8 "	8	2 sec.
	5 "	6	-----
B. fervidus	15 "	9	-----
B. fervidus	1 "	2	-----
B. fervidus	10 "	15	2 sec.
	8 "	6	-----
B. fervidus	10 "	5	-----
B. americanorum	10 "	3	2 sec.
	5 "	6	2 sec.
	30 "	7	-----

Similar observations were made on August 6, 1910, in a field of red clover on the University farm. Time 3 p. m., weather warm and dry.

Species	Time spent on clover head	No. florets visited	Time in flight to next head
B. americanorum	20 sec.	14	2 sec.
	30 "	10	2 "
	15 "	12	3 "
	3 "	2	-----
B. americanorum	15 "	9	-----
B. americanorum	35 "	11	1 sec.
	5 "	2	-----
B. fervidus	20 "	13	-----
B. fervidus	35 "	16	2 sec.
	15 "	8	2 "
	8 "	4	2 "
	8 "	6	10 "
	6 "	5	2 "
	8 "	4	-----

INQUILINES AND ENEMIES.

The most extensive American account of this subject was published by Packard in 1864 in the Proceedings of the Essex Institute, Vol. IV, pp. 118--153. All our subsequent accounts consist only of brief notices scattered through the literature.

Among inquilines the most important are the species of Psithyrus. My records show that a large percentage of the nests of Bombus in this locality are infested with Psithyrus variabilis.

Between Sept. 20 and Oct. 3, 1910, thirty-five females and eleven males were found in one nest of B. americanorum. Doubtless there were many more which escaped observation.

Another nest of B. americanorum was examined Oct. 9, 15 and 18, 1910. Fifty males of Psithyrus variabilis were taken in and just outside the nest.

Very frequently a nest of Bombus in autumn will contain more individuals of Psithyrus than of the rightful occupants. That they are detrimental to the Bombus colony can hardly be doubted. Perhaps the name parasite would be more appropriate than inquiline.

Mites are numerous in bumblebees' nests, but as the bees usually occupy abandoned field mouse nests, it is probable that the mites come from the mice.

In the observation boxes I have frequently seen ants, Monomorium minutum, and nymphs of cockroaches, species not determined.

During the winter I kept in the laboratory a lot of comb

from a last year's nest of Bombus fervidus. On Feb. 3, 1911, I saw in this about thirty larvae and one pupa of Vitula edmandsii Pack., also a moth, probably of the same species which escaped. The larvae spun loose cocoons recalling those of Galleria mellonella. The larvae were eating the pollen and wax contained in the old nest. I succeeded in rearing six moths from this lot of larvae and found the pupal period to be ten days.

On August 16, 1910, an adult Podisus maculiventris was found near a nest of Bombus fervidus with its beak thrust into the neck of a worker which it had evidently killed.

During the late summer and autumn of 1910, nine conopid puparia were taken from the abdomens of as many dead workers of Bombus americanorum. They were placed in vials for the purpose of getting the flies if any should emerge. Only one emerged before the day required for the completion of this thesis. Unfortunately, it died before the wings expanded and the colors developed, so that the species could not be determined with certainty. From three of the puparia there emerged numerous hymenopterous parasites, Nestocharis williamsoni Girault MSS. The emergence of the different lots occurred May 20, 26, and 27, 1911.

II. SYSTEMATIC.

Synopsis of the Bombidæ of Illinois.

In this key the word female signifies both queens and workers.

Inner tarsal claws short. Antennæ not longer than the thorax. Provided with a sting.

Females.

Inner tarsal claws almost as long as the outer. Antennæ usually longer than the thorax, but when this is not the case, the eyes and ocelli are large and prominent. Not provided with a sting.

Males.

Females

Posterior tibiæ with corbícula. Queens and workers.

Bombus

Posterior tibiæ without corbícula. Apex of abdomen curved under. No workers.

Psithyrus

Males

Eyes not narrower than cheeks. Genitalia corneous. Hairs of front usually shorter and less dense than in the next genus.

Bombus

Eyes relatively small, narrower than the cheeks. Genitalia chiefly membranous. Front densely covered with long hairs.

Psithyrus

Key to the Illinois Species of Bombus.

Females

I. Dorsum of thorax with a transverse or rounded patch of black between the wings

1. Abdominal segments 3--6 black..... scutellaris
2. Abdominal segments 5--6 black..... fervidus
3. Abdominal segments 4--6 black
 - a. Posterior margin of first abdominal segment yellow. Vertex black..... americanorum
 - b. Posterior margin of first abdominal segment black. Vertex yellow..... pennsylvanicus

II. Dorsum of thorax entirely yellow or with a few black hairs on the disk

1. Abdominal segments 2--6 black..... virginicus
2. Abdominal segments 3--6 black
 - a. Second abdominal segment entirely yellow

vagens and
consimilis
 - b. Second abdominal segment partly yellow, the remainder black ridingsii
 - c. Second abdominal segment partly tawny, the remainder black..... separatus

Males

- I. Dorsum of thorax with a transverse or rounded patch of black between the wings
 1. Eyes large and prominent, almost contiguous
 - a. Abdominal segments 4--7 black..... pennsylvanicus
 - b. Abdominal segments 3--7 black..... scutellaris
 2. Eyes of normal size
 - a. Dorsal band narrow. Abdominal segments 5--7 always black..... fervidus
 - b. Dorsal band broad. Abdominal segments 5--7 variable in color..... americanorum
- II. Dorsum of thorax entirely yellow or with a few black hairs on the disk
 1. Abdominal segments 2--7 black..... virginicus
 2. Abdominal segments 3--7 black
 - a. Second abdominal segment entirely yellow
vagens
 - b. Second abdominal segment partly yellow, the remainder black..... ridingsii
 - c. Second abdominal segment partly tawny, the remainder black..... separatus

Note:--Consimilis is omitted from this key on account of the lack of material.

BOMBUS Latr.

Synonymy

1758.	Apis (in part)	Linnaeus	Syst. Nat. p. 574
1802.	Bombus	Latreille	Hist. Nat. Ins. XIV, 63
1807.	Bremus	Jurine	Hym. p. 259.
1836.	Bombus	St. Fargeau	Hist. Nat. Ins. Hym. I, 436
1854.	Bombus	Smith	Brit. Mus. Cat. Hym. I, 385
1887.	Bombus	Cresson	Trans. Am. Ent. Soc., Suppl. Vol. p: 130
1889.	Bombus	Ashmead	Trans. Am. Ent. Soc. XXVI, 54, 57
1903.	Bombus (in part)	Robertson	Trans. Am. Ent. Soc. XXIX, 176
1903.	Bombias (in part)	Robertson	Trans. Am. Ent. Soc. XXIX, 176

DESCRIPTION (Adapted from Ashmead).

Three sexes, or castes; queens, workers, and males.

Body densely hairy. Hypopharynx or tongue very elongate, slender, and longer than the mentum. Labrum transverse, subtrapezoidal, the clypeus not carinate. Labial palpi 4-jointed; maxillary palpi short, 2-jointed. Malar space large, distinct. Scutellum sinicircular, rounded off posteriorly, and not projecting over the metanotum. Hind tibiae with two apical spurs. Queens and workers have a corbiculum and a dense polliniferous scopa and the hind tibia and basal tarsal segment.

The writer is not ready to accept the new genus Bombias proposed by Robertson in his synopsis of the Bombidae. The characters used by that author in describing Bombias are useful in a table for separating species, but they are not, in my opinion,

sufficiently important to establish a genus. The genus Bombus has long been established and is clearly defined. Nothing can be gained by breaking it up on account of variations in the size and position of the ocelli. While several recent entomologists have followed Robertson, the writer agrees with Franklin, that eventually Bombias will be ranked as a subgenus only.

While most people are unable to distinguish between the species of Bombus and other bees of large size, there is only one genus which ever gives any difficulty to an entomologist. That is the genus Psithyrus, the males of which require very close examination in order to be distinguished from certain Bombus males. The earlier writers on North American bumblebees were greatly troubled by this difficulty, and as a result, for many years a pseudo-species, Apathus elatus, was frequently referred to in entomological literature.

The quickest and surest way to determine what genus a male specimen should be referred to is to examine the genitalia, which can be extruded easily in a fresh or relaxed specimen. In Psithyrus these organs are largely membranous and apparently simple in structure. In Bombus they are corneous and composed of several jointed plates.

On account of the difficulty mentioned, it is thought best to prefix the key to the Bombus species of Illinois with a table for separating Bombus and Psithyrus.

BOMBUS VIRGINICUS Oliv.

Synonymy

- | | | | |
|-------|--------------------------|-------------|--|
| 1789. | <i>Apis virginicus</i> | Olivier | Encycl. meth. ins. IV, 66. |
| 1793. | <i>Apis virginica</i> | Fabricius | Ent. Syst. II, 318 |
| 1804. | <i>Bombus virginicus</i> | Fabricius | Syst. Piez., p. 346 |
| 1836. | <i>Bombus virginicus</i> | St. Fargeau | Hym. I, 470 |
| 1837. | <i>Bombus virginicus</i> | Kirby | Faun. Bor. Am. IV, 274 |
| 1854. | <i>Bombus virginicus</i> | Smith | Brit. Mus. Cat. Hym. I, 398 |
| 1862. | <i>Bombus virginicus</i> | Greene | Ann. Lyc. Nat. Hist. N. Y., VII, 170 |
| 1863. | <i>Bombus virginicus</i> | Cresson | Proc. Ent. Soc. Phila. II, 87 (in part). |
| 1863. | <i>Bombus virginicus</i> | Cresson | ibid, p. 166. |
| 1864. | <i>Bombus virginicus</i> | Packard | Proc. Essex Inst. IV, 113 |
| 1887. | <i>Bombus virginicus</i> | Cresson | Trans. Am. Ent. Soc., Suppl. Vol., p. 308. |
| 1902. | <i>Bombus virginicus</i> | Titus | Can. Ent. XXXIV, 37 |
| 1903. | <i>Bombus virginicus</i> | Robertson | Trans. Am. Ent. Soc. XXIX, 176. |

FEMALE.

Average length 21 mm.

Head black, length of front 6 mm.; width, including the eyes 5 mm. Pubescence yellow on the vertex with a few black hairs ; sides of face and front black with a slight mixture of greyish or yellowish above the insertion of the antennae. Ocelli small, in line with the upper edge of the eyes. Length of antennae 8 mm. "Labrum with basal ridge forming a subquadrate sinus nearly reaching the apical margin."

Length of thorax 10--11 mm.; width, 10 mm. Yellow above and

on sides. Black beneath.

Wings subhyaline, smoky toward the edges. Veins brown.

Expanse 40--44 mm.

Legs black; base of femora beneath sometimes clothed with yellow hairs; tarsi brown with basal joint rufous on inner side.

Length of abdomen 12--14 mm; width 11 mm. Basal segment yellow above and on sides. Remainder of segments black. Black beneath.

WORKER.

Colored the same as the female except that the wings are paler.

Nine specimens have an average length of 15 mm. and an alar expanse of 31 mm.

MALE.

Average length 15 mm.

Head 4 mm. long in front. Width, including the eyes, 4 mm. Pubescence long. Yellow on vertex, cheeks and front below antennae. Black on front above antennae. Clypeus covered with yellow hairs. Ocelli small, in a straight line even with upper edge of eyes. Eyes narrow; front broad. Length of antennae 7 mm.

Length of thorax 5 mm., width, 6 mm. Clothed with long yellow hairs above, on sides, and beneath; sometimes there is a mixture of black hairs on the disk.

Wings hyaline; veins brown. Expanse 31 mm.

Legs brown with yellowish hairs.

Abdomen 8 mm. long, 6 mm. wide. First segment yellow above

with a slight indentation on the apical margin. Remainder black or dark brown, yellowish beneath.

Data of Material Studied or Observed

Date	Caste	Habitat	Locality	Collection	Remarks
Apr. 28, '11	1 queen	Woods	Urbana, Ill.	----	Prospecting
May 4, '90	1 queen	Woods	Urbana, Ill.	Lab. Nat. Hist.	C. A. Hart, Coll.
May 10, '11	Many queens	On horse chestnut	" "	----	Feeding
May 10, '11	1 queen	On ground	" "	----	Prospecting
May 14, '11	1 queen	On dandelion	Champaign, Ill.	Personal, W. W.	Dr. Folsom, Coll.
June, '07	1 queen	----	Urbana, Ill.	Ent. Dept.	----
June 26, '07	1 queen	In orchard	" "	" "	----
July 10, '03	1 worker	On red clover	" "	" "	Dr. Folsom, Coll.
July 13, '03	1 worker	On red clover	" "	" "	" "
July 15, '13	1 worker	On red clover	" "	" "	" "
Aug. 3, '85	1 worker	----	" "	Lab. Nat. Hist.	----
Aug. 11, '90	1 male	Woods	" "	" "	Marten, Coll.
Sept., '83	1 male	----	Normal, Ill.	" "	----
Oct. 2, '83	1 male	----	" "	" "	----
Oct. 3, '83	1 male	----	" "	" "	----
Oct. 9, '85	1 worker	----	Champaign, Ill.	" "	----
-----	1 male	----	----	" "	----
-----	1 queen	----	Knoxville, Ill.	Personal, W. W.	H. J. Vanderveave, Coll.
-----	2 males	----	----	Bolter	----
-----	1 queen	----	----	"	----
-----	4 workers	----	Algonquin, Ill.	Nason	----

BOMBUS FERVIDUS Fabr.

Synonymy

1798. <i>Apis fervida</i>	Fabricius	Ent. Syst. Suppl. 274
1804. <i>Bombus fervidus</i>	Fabricius	Syst. Piez. 352
1836. <i>Bombus fervidus</i>	St.Fargeau	Hist.Nat.des ins., hym. I, 470
1862. <i>Bombus fervidus</i>	Greene	Ann.Lyc.Nat.Hist. N.Y., VII, 171
1863. <i>Bombus fervidus</i>	Cresson	Proc.Ent.Soc.Phila., II, 93.
1864. <i>Bombus fervidus</i>	Packard	Proc.Essex Inst.,IV,107.
1902. <i>Bombus fervidus</i>	Titus	Can.Ent., XXXIV, 38.
1903. <i>Bombus pennsylvanicus</i> Robertson		Trans.Am.Ent.Soc.,XXIX, 176.
1907. <i>Bombus fervidus</i>	Lovell	Ent. News XVIII, 195.

QUEEN.

Average length, 21 mm. Robust, of moderate size. Conspicuously yellow in flight.

Head black; length of front 6 mm.; width, including the eyes, 5 mm. Hairs on vertex and cheeks black. Hairs on front black, with a mixture of greyish above the insertion of the antennae. Length of antennae, 7 mm. Ocelli small, in line with upper edge of eyes. Labrum with widely separated tubercles at the base.

Length of thorax 9 mm., width 10 mm. Dorsal surface of thorax bright yellow except a narrow black band connecting the bases of the wings. Sides yellow. Body black ventrally.

Wings smoky hyaline with violet reflections. Veins brown. Expanse 40 mm.

Legs black: tibiae with black hairs on the tip and along the sides. First tarsal joint dark fuscous above, lighter beneath.

Length of abdomen 14 mm., width 10 mm. First four segments yellow above. Remainder black.

WORKER.

Coloration similar to that of the queen, average measurements as follows:

	Foragers	Medium sized Workers	Smallest Workers
Length	18 mm.	15 mm.	12 mm.
Alar expanse	35 mm.	29 mm.	21 mm.

MALE.

Average length, 18 mm.

Head black; length of front 5 mm.; width, including the eyes, 4 1/2 mm. Pubescence on vertex, cheeks and front, black. A few yellow hairs above the insertion of the antennae. Length of antennae, 8 mm. Clypeus bare, sparingly punctate.

Length of thorax, 6 mm.; width, 6 mm. Dorsum of thorax yellow with a black band connecting the bases of the wings. Sides yellow. Body black beneath.

Wings smoky, paler in the closed cells. Expanse 33 mm.

Legs black. Tibiae with yellow hairs. Basal segments of tarsi, rufous.

Length of abdomen 10 mm., width, 7 mm. First four segments yellow above, the remainder black. Abdomen black beneath with a few short yellow hairs toward the sides.

This is a common American species which Fabricius doubtless had in hand when he gave his description of Apis fervida in 1798.

Six years later the same author supplemented his description under the name of Bombus fervidus and this name has been adopted by all subsequent writers except Robertson, who put it as a synonym of Bombus pennsylvanicus DeG. I can find no good reason for this departure, especially since both Cresson and Packard defined the name fervidus with their adequate redescription.

Data of Material Studied or Observed

Date	Caste	Habitat	Locality	Collection	Remarks
Apr. 28, '11	1 queen	Woods	Urbana, Ill.	----	Observed by W. W.
May 5, '11	Several queens	On apple blossoms	Savoy, Ill.	----	" " " "
May 10, '11	2 queens	On dandelion	Urbana, Ill.	----	" " " "
May 21, '11	Many queens	On red clover	Champaign, Ill.	----	" " " "
June 3, '10	1 queen	On red clover	" "	Personal, W. W.	W. W., Coll.
July 16, '10	1 queen	In nest	Urbana, Ill.	----	Kept for Exp.
July 16, '10	16 workers	" "	" "	----	" " " "
July 29, '85	1 worker	----	" "	Lab. Nat. Hist.	----
July 29, '85	4 workers	On red clover	" "	----	Observed by W. W.
July 30, '85	1 queen	Woods	" "	Lab. Nat. Hist.	Marten, Coll.
Aug. 1, '90	1 worker	----	" "	" "	----
Aug. 3, '85	1 worker	On red clover	" "	----	Observed by W. W.
Aug. 6, '10	2 workers	On thistle	" "	Lab. Nat. Hist.	----
Aug. 20, '85	1 worker	Herbage	Champaign, Ill.	Nason	----
Sept. 7, '96	1 worker	Near nest	Algonquin, Ill.	Personal, W. W.	W. W., Coll.
Sept. 10, '10	1 queen	" "	Urbana, Ill.	" "	1 taken
Sept. 10, '10	Several males	" "	" "	" "	W. W., Coll.
Sept. 24,	6 males	On thistle	Northern Ill.	Bolter	
	3 workers		" "	" "	
	2 queens		Algonquin, Ill.	Nason	
	3 queens	----	" "	" "	
	12 workers	----	" "	" "	
	3 males	----	" "	" "	

BOMBUS AMERICANORUM Fabr.

Synonymy

1775.	<i>Apis americanorum</i>	Fabricius	Syst. Ent. p. 380
1793.	<i>Apis americanorum</i>	Fabricius	Ent. Syst. II, 319
1798.	<i>Apis elata</i>	Fabricius	Ent. Syst. Suppl. p. 274 (male).
1798.	<i>Apis nidulans</i>	Fabricius	ibid (male)
1804.	<i>Bombus americanorum</i>	Fabricius	Syst. Piez. p. 346
1804.	<i>Bombus nidulans</i>	Fabricius	ibid p. 349 (male)
1836.	<i>Bombus americanorum</i>	St. Fargeau	Hym. I, 472
1854.	<i>Bombus americanorum</i>	Smith	Brit. Mus. Cat. Hym. I, 398
1862.	<i>Bombus americanorum</i>	Greene	Ann. Lyc. Nat. Hist. N.Y., VII, 172
1863.	<i>Apathus elatus</i>	Cresson	Proc. Ent. Soc. Phila, II, p. 114, (male).
1863.	<i>Bombus pennsylvanicus</i>	Cresson	Proc. Ent. Soc. Phila. II, 94 (in part).
1887.	<i>Apathus? elatus</i>	Cresson	Trans. Am. Ent. Soc. Suppl. Vol., p. 307
1890.	<i>Bombus americanorum</i>	Robertson	Ent. News I, 39
1897.	<i>Bombus americanorum</i>	Robertson	Trans. Acad. Sci. St. Louis, VII, 356
1902.	<i>Bombus pennsylvanicus</i>	Titus	Can. Ent. XXXIV, 38 (female).
1903.	<i>Bombus americanorum</i>	Robertson	Trans. AM. Ent. Soc. XXIX, 176

QUEEN.

Length of body 23 mm. Large, conspicuously black, with bright yellow on front of the thorax and on the abdomen. Head entirely black; length of front 7 mm.; width, including eyes, 6 mm. Hairs on vertex, cheeks and front, black. Ocelli small, in

line with upper edge of eyes. Length of antennae 2 mm. Labrum with a tubercle at each end of its base.

Thorax with a yellow band in front of the wings and a slight mixture of yellow hairs on the scutellum, remainder black.

Length 9 mm., width 10 mm.

Wings dark fuscous with violet reflections. Expanse 46 mm.

Legs dark brown to black, with black hairs. Tarsi paler.

Abdomen, length 15 mm., width 11 mm. "First segment yellow, mixed with black on the lateral basal angles, or the entire basal portion black; the apical margin always yellow, the yellow hairs more abundant in the middle." Second and third segments yellow. Remainder black, also entirely black beneath.

WORKER.

Colored the same as the female. There are three sizes with average measurements as follows:

	Foragers	Medium Sized Workers	Smallest Workers
Length	20 mm.	16 mm.	11 mm.
Width of thorax	10 mm.	7 mm.	5 mm.
Alar expanse	40 mm.	37 mm.	23 mm.

MALE.

Length of body 18--20 mm. Length of head in front 6 mm.; width, including the eyes, 5 mm. Hairs on vertex and cheeks black. Front black with a few greyish yellow hairs above the insertion of the antennae. Length of antennae, 10 mm.

Thorax yellow above and on sides. A black band between the wings. Length 7 mm.; width 8 mm.

Wings smoky. Expanse 38--40 mm.

Legs dark brown to black; femora clothed with yellow hairs.

Abdomen, length 10--12 mm. Width 8 mm. "Segments 1--4 yellow; 5--7 yellow-black or fulvous, or yellow with fulvous tip, yellow with black tip, or black with fulvous tip." Dark brown or black below, sometimes with yellow hairs on apical margins of segments.

The synonymy of this species was in a state of confusion until 1890, when Robertson made it clear (Ent. News, I, 39). His synonymical list is incorporated into mine, but does not include the reference to Smith, 1854, nor any, of course, after 1890.

The name Apathus elatus is now known to include the males of both B. fervidus and B. americanorum. Robertson very clearly pointed out the distinctions between the queens and workers of this species and those of pennsylvanicus. That, however, did not prevent Titus from making the error, in his table of the Colorado Bombidae, of saying that the vertex of the female is all black.

Data of Material Studied or Observed

Date	Caste	Habitat	Locality	Collection	Remarks
Apr. 18, '90	Queen	Woods	Urbana, Ill.	Lab. Nat. Hist.	C. A. Hart, Coll.
Apr. 26, '90	"	-----	"	"	"
Apr. 28, '91	"	Woods	"	-----	Observed by W. W.
May 5, '11	Several queens	On apple blossoms	Savoy, Ill.	-----	"
May 10, '11	"	On horse chestnut	Urbana, Ill.	-----	"
May 14, '11	"	On dandelion	Champaign, Ill.	-----	"
June 15, '10	1 queen	On clover	Urbana, Ill.	-----	"
July 10, '10	1 worker	"	"	-----	"
July 18, '81	1 worker	-----	Normal, Ill.	Lab. Nat. Hist.	-----
July 20, '10	1 queen	In nest	Urbana, Ill.	-----	Observed by W. W.
July 20, '10	8 workers	"	"	-----	"
July 21, '94	1 worker	-----	Algonquin, Ill.	Nason	-----
July, '79	2 workers	"	Adams Co., Ill.	Lab. Nat. Hist.	-----
July 30, '10	5 workers	On red clover	Urbana, Ill.	-----	Observed by W. W.
Aug. 1, '90	1 worker	Woods	"	Lab. Nat. Hist.	Marten, Coll.
Aug. 6, '10	3 workers	On red clover	"	-----	Observed by W. W.
Aug. 20, '10	3 " 1 male	"	"	-----	W. W., Coll.
Sept. 2, '89	1 male	-----	"	Lab. Nat. Hist.	Marten, Coll.
Sept. 16, '90	1 worker	On red clover	"	"	C. A. Hart, Coll.
Sept. 19, '87	1 male	On Helianthus	"	"	Weed, Coll.
Sept. 21, '87	1 " 10 males	"	"	"	"
Sept. 25, '11	3 females	On thistle	Champaign, Ill.	-----	W. W., Coll.
-----	17 females	-----	Algonquin, Ill.	Nason	
-----	3 workers	-----	"	"	
-----	3 females	-----	Northern Ill.	Bolter	
-----	5 workers	-----	"	"	
-----	8 males	-----	"	"	

BOMBUS RIDINGSII Cress.

Synonymy

1878. *Bombus ridingsii* Cresson Proc. Acad. Nat. Sci. Phila.,
1878, p. 182.
1887. *Bombus ridingsii* Cresson Trans. Am. Ent. Soc. Suppl. Vol.
308.
1903. *Bombus ridingsii* Robertson Trans. Am. Ent. Soc. XXIX, 176

QUEEN.

Average length 21 mm.

Length of head in front, 7 mm.; width including the eyes, 5 mm. Pubescence black on front and cheeks, a few yellow hairs above the insertion of the antennae. Vertex yellow. Ocelli small, in line with upper edge of the eyes. Eyes narrow. Length of antennae, 7 mm.

Length of thorax, 8 mm.; width, 8 mm. Lemon yellow above and on sides. A few black hairs on the disk.

Wings smoky, cells hyaline, veins brown; expanse 41 mm. Legs black, basal joint of hind tarsi rufous on inner surface.

Length of abdomen 11 mm.; width, 10 mm. First segment lemon-yellow above. Second segment lemon-yellow on basal middle. Remainder of abdomen black.

WORKER.

Colored the same as the female. One specimen in the Ill. State Lab. Nat. Hist. collection is 14 mm. long and has an alar expanse of 31 mm.

MALE.

Length of body 16 mm.

Length of head in front, 4 mm; width, including the eyes,

4 mm. Cheeks black. Front and vertex yellow. Ocelli small, in line with upper edge of eyes. Eyes small, front broad. Length of antennae 8 mm.

Length of thorax, 6 mm.; width, 6 mm.; yellow above and on the sides. Disk with a few black hairs.

Wings subhyaline, nervures brown. Expanse 31 mm.

Legs dark brown or black; femora clothed with long yellow hairs.

Length of abdomen, 8 mm; width, 7 mm. First segment yellow above. "Second segment yellow above, more or less black on sides and apical middle. Segment 4 sometimes a little yellow."

VARIATIONS:--In some specimens of the queens and workers the yellow on the middle of the second segment extends to the posterior margin and is more or less divided posteriorly, forming two spots.

"Allied to separatus Cress., which, however, has the pubescence of the head entirely black and that on basal middle of second abdominal segment more or less tinged with brown, and never divided."

Quoted from original description.

Data of Material Studied or Observed

Date	Caste	Habitat	Locality	Collection	Remarks
Apr. 24, '11	2 queens	On Dicentra	Urbana, Ill.	-----	Observed by W. W.
Apr. 28, '11	3 queens	"	"	Personal, W. W.	" " "
Apr. 30, '11	Many queens	In woods	"	-----	" " Folsom
May 7, '11	Several queens	On dandelion	Champaign, Ill.	-----	" " W. W.
May 10, '11	Many queens	On horse chestnut	"	-----	" " "
July 24, '79	1 worker	-----	Heyworth, Ill.	Lab. Nat. Hist.	-----
Aug. 3, '98	1 male		Herod, Pope Co.	Lab. Nat. Hist.	C. A. Hart, Coll.
	1 worker		Southern Ill.	" "	C. Robertson, Coll.
	1 worker		Algonquin, Ill.	Nason	

BOMBUS VAGANS Smith.

Synonymy

- | | | | |
|-------|---------------|---------|---|
| 1854. | Bombus vagans | Smith | Brit. Mus. Cat. Hym. I, 399 |
| 1863. | Bombus vagans | Cresson | Proc. Ent. Soc. Phila., II, 91 |
| 1864. | Bombus vagans | Packard | Proc. Essex Inst., IV, 115 |
| 1887. | Bombus vagans | Cresson | Trans. Am. Ent. Soc., Suppl Vol.,
p. 308 |
| 1902. | Bombus vagans | Titus | Can. Ent. XXXIV, 37 |

QUEEN.

The writer has not seen the queen of this species. According to authors it is small and rather plump. Average length, according to Packard, .73 inch.

The head is black with a yellow tuft on the vertex and below the antennae.

The dorsum of the thorax is yellow, or with a few black hairs on the disk. Alar expanse, according to Packard, 1.04 inch. Legs black.

Abdominal segments 1--2 yellow; remainder black.

WORKER.

The coloration of the workers is similar to that given for the queen. Several of those examined by me have a few yellow hairs at the base of the femora beneath. Two sizes have been recognized by me, averaging in length 15 mm. and 13 mm.

MALE.

Length 12--13 mm.

Length of head in front 3 mm.; width, including eyes, 3 mm.

Vertex, cheeks, and front including the clypeus, covered with yellow hair. Length of antennae, 6 mm. Ocelli small, in line with upper edge of eyes.

Length of thorax, 5 mm.; width 6 mm. Pale yellow above, on sides and beneath.

Wings subhyaline; veins brown. Expanse 26 mm.

Legs black; femora with yellowish hairs.

Length of abdomen 6 mm., width 6 mm. First two segments pale yellow above, remaining segments black above. All segments have short yellow hairs beneath.

Data of Material Studied

Date	Caste	Habitat	Locality	Collection	Remarks
July 4, '07	1 worker		Urbana, Ill.	Ent. Dept.	
July 18, '81	2 workers		Normal, Ill.	Lab. Nat. Hist.	
Aug. 4, '79	1 worker		Bloomington, Ill.	Lab. Nat. Hist.	
Aug. 20, '85	1 worker	On thistle	Champaign, Ill.	" "	
Sept. 5, '85	1 "		" "	" "	
Sept. 20, '85	1 male	On aster	Urbana, Ill.	" "	Weed, Coll.
	2 males		Algonquin, Ill.	" "	
	9 workers		" "	Nason	
	4 males		" "	" "	
	3 workers		" "	Bolter	
	1 male		" "	" "	

BOMBUS CONSIMILIS Cress.

Synonymy

1864. *Bombus consimilis* Cresson Proc. Ent. Soc. Phila. III,
41.
1887. *Bombus consimilis* Cresson Trans. Am. Ent. Soc., Suppl.
Vol., p. 307
1903. *Bombus consimilis* Robertson Trans. Am. Ent. Soc., XXIX,
76
1907. *Bombus consimilis* Lovell Ent. News, XVIII, 195

QUEEN.

According to authors this species is not large, but robust.

Head black, vertex yellow. Ocelli small and in line with the upper edge of the eyes. Labrum with two tubercles at the base. Clypeus bare, convex, polished.

Thorax yellow, with a few black hairs on the disk.

Wings ^{sub}hyaline, smoky toward the base. Legs black. First two abdominal segments yellow, remainder black.

One specimen in the Bolter collection has the above described coloration, and has measurements as follows: Length 17 mm. Length of head in front 5 mm.; width, including the eyes, 5 mm. Antennae 6 mm. Length of thorax 7 mm., width, 9 mm. Alar expanse 35 mm. Length of abdomen 9 mm., width, 10 mm.

WORKER.

One specimen in the Bolter collection labeled consimilis answers to the description of the queen except that the vertex is black and the second abdominal segment is tawny, and it is smaller, having a total length of 14 mm. and an alar expanse of 32 mm.

MALE.

This is described by authors as having the eyes small, front broad, vertex yellow and a tuft of yellow hairs below the antennae. The mesonotum is yellow, usually with black hairs on the disk. Abdominal segment 1 yellow, 2 largely yellow.

The above descriptions, being chiefly compilations, are not satisfactory but are the best that can be given under the circumstances. I have seen only three specimens labeled consimilis, and one of these, the male, is doubtfully referred to this species, while the others agree very closely with the published descriptions of vagans.

Cresson, in the original description of consimilis, says that it is colored the same as vagans but is smaller and more robust. He had previously redescribed vagans but no other writer has ever published descriptions of both species.

With the material and literature at my disposal, I am unable to separate the two species.

BOMBUS PENNSYLVANICUS DeG.

Synonymy

1773. *Apis pensilvanica* DeGeer Mem. II, 575
 1863. *Bombus pennsylvanicus* Cresson Proc.Ent.Soc.Phila.,II,94
 1864. *Bombus pennsylvanicus* Packard Proc.Essex.Inst.,Iv, 111
 1890. *Bombus pennsylvanicus* Coville Proc.Ent.Soc.Wash.,I,202
 1890. *Bombus pennsylvanicus* Robertson Ent. News, I, 39
 1903. *Bombus auricomus* Robertson Trans.Am.Ent.Soc.,XXIX,176
 1907. *Bombus auricomus* Swenk Ent. News, XVIII, 294

QUEEN.

Average length 25 mm.

Length of head in front, 7 mm.; width including eyes, 6 mm. Pubescence on sides and front black; vertex yellow. Length of antennae 9 mm. "Base of labrum with a transverse narrowly interrupted ridge".

Length of thorax 10 mm., width 11 mm. Pubescence in front of wings and on the pleura yellow. Scutellum more or less yellow. Between the wings black. Beneath black.

Wings dark fuscous with violaceous reflections. Expanse 50--55 mm.

"Legs black; tarsi brown, basal joint rufous on the inner side."

Length of abdomen, 14 mm.; width 12 mm. First segment black, or with a little yellow on the sides and with the median portion of the posterior margin always black. Second and third segments yellow above, the remaining segments black. Beneath, entirely black.

WORKER.

Similar to the queen in coloration. The average length of the foragers is 19 mm., and the alar expanse is 43 mm.

MALE.

Average length, 21.5 mm.

Length of head in front, 5 mm.; width including the eyes, 5 mm. Eyes large and prominent, almost contiguous. Front narrow. Ocelli large, almost contiguous. Pubescence on front and cheeks yellow, sometimes with a slight mixture of black hairs. Length of antennae, 7 mm.

Length of thorax, 8--9 mm., width, 8--9 mm. Thorax yellow above and on sides and with a transverse or rounded patch of black between the wings.

Wings fusco-hyaline, darkest along the costa and toward the base. Expanse, 40--45 mm.

Length of abdomen, 11 mm. First segment yellow mixed with black at the base. Second and third segments yellow; remaining segments black. Abdomen black beneath with a few pale hairs.

The queens and workers of this species closely resemble those of B. americanorum so that it is impossible to distinguish them in flight. A close examination, however, will show the following distinctive characters: The vertex of pennsylvanicus is always more or less yellow, while that of americanorum is always black; the first abdominal segment of pennsylvanicus is black or has a little yellow on the sides. It is never yellow on the apical middle. In americanorum the entire posterior margin of the first segment is yellow. In pennsylvanicus, the base

of the labrum when seen from above shows a transverse ridge, more or less interrupted medially. The labrum of americanorum has a tubercle at each end of its base. The above distinctions were first pointed out by Robertson (Ent. News, I, p. , 1890).

The first adequate and recognizable description of this species was given by Cresson who made an error, however, in supposing that B. americanorum Fabr. is one of its varieties. Robertson, in 1890, pointed out the mistake and showed that the two are distinct species.

The writer is not ready to accept the new name Bombias auriconus Robertson. For reasons already given, the erection of a new genus seems unwarranted. In regard to the specific name, the displacement of pennsylvanicus can be made only on the assumption that it belongs where fervidus has stood and that the latter name should be thrown out entirely. As an argument against this, we may compare the completeness of Fabricius supplemented description of Bombus fervidus with the inadequateness of DeGeer's description of Apis pensilvanica.

Altho it is mere guess-work to say what species DeGeer had in mind, there are several reasons for following Cresson rather than Robertson.

Cresson gives us the first adequate description of the species. His work was done forty years before that of Robertson and his conclusions were accepted by his contemporary, Packard, and by other writers since his time, including Robertson himself as late as 1890. Finally, Robertson makes the change arbitrarily without giving any evidence or explanation.

Data of Material Studied or Observed

Date	Caste	Habitat	Locality	Collection	Remarks
Mar. 2, '07	1 queen	In a greenhouse	Urbana, Ill.	Ent. Dept.	Observed by W. W.
Apr. 28, '11	1 queen	On Trillium	Urbana, Ill.	-----	" " " "
May 5, '11	Several queens	On horse chestnut	Urbana, Ill.	-----	" " " "
May 10, '11	Many queens	On apple blossoms	Savoy, Ill.	-----	" " " "
May 14, '11	2 queens	On dandelion	Champaign, Ill.	-----	" " " "
May 21, '11	3 queens	On red clover	Champaign, Ill.	-----	" " " "
May 29, '90	1 queen		Urbana, Ill.	Lab. Nat. Hist.	-----
June 26, '07	1 queen	On garden flowers	Urbana, Ill.	Ent. Dept.	A. A. Hummel, Coll.
July 15, '03	4 workers	On red clover	Urbana, Ill.	Ent. Dept.	J. W. Folsom, Coll.
July 16, '03	1 worker	On red clover	Urbana, Ill.	Ent. Dept.	" " " "
July 28, '91	1 worker	-----	Urbana, Ill.	Lab. Nat. Hist.	Terrill, Coll.
July 30, '07	8 workers	On red clover	Urbana, Ill.	Lab. Nat. Hist.	A. A. Hummel, Coll.
July 30, '91	1 male	-----	Champaign, Ill.	Lab. Nat. Hist.	Marten, Coll.
Aug. 9, '91	1 male	-----	Grand Tower, Ill.	Lab. Nat. Hist.	C. A. Hart, Coll.
Aug. 22, '89	1 male	-----	Champaign, Ill.	Lab. Nat. Hist.	Marten, Coll.
-----	1 queen			Bolter	-----
-----	6 queens	-	Algonquin, Ill.	Nason	-----
-----	1 queen		Southern Ill.	Lab. Nat. Hist.	C. Robertson, Coll.
-----	1 worker		Southern Ill.	Lab. Nat. Hist.	C. Robertson, Coll.
-----	1 male		Southern Ill.	Lab. Nat. Hist.	C. Robertson, Coll.
-----	1 worker		Camp Point, Ill.	Lab. Nat. Hist.	-----

BOMBUS SCUTELLARIS Cress.

Synonymy

- | | | | |
|-------|---------------------------|-----------|---|
| 1863. | <i>Bombus scutellaris</i> | Cresson | Proc. Ent. Soc. Phila. II,
96 |
| 1887. | <i>Bombus scutellaris</i> | Cresson | Trans. Am. Ent. Soc. Suppl. Vol.
p. 308. |
| 1902. | <i>Bombus scutellaris</i> | Titus | Can. Ent. XXXIV, 38 |
| 1903. | <i>Bombus scutellaris</i> | Robertson | Trans. Am. Ent. Soc., XXIX,
176. |

FEMALE.

The writer has not seen the queen of this species. According to authors, it does not differ from the workers except in size. Cresson gives its length as 13 lines (1.08 in.).

WORKER.

The measurements here given are for the largest size.

Length of body 20 mm.

Length of head in front, 6 mm. Width, including eyes, 5 mm. Eyes prominent. Ocelli large, below upper edge of eyes. Pubescence on head entirely black. Length of antennae, 7 mm.

Length of thorax 8 mm.; width, 9 mm.; yellow above except a black band between the wings. Sides yellow.

Wings subhyaline, smoky along the nervures. Veins brown. Expanse 41 mm.

Legs dark brown with black pubescence. Tarsi paler.

Length of abdomen 12 mm. Width, 9 mm. First two segments yellow above, the others black. Beneath black.

MALE.

Length, 23 mm.

Length of head in front 6 mm.; width, including the eyes,

6 mm. Pubescence on vertex and below insertion of antennae black mixed with yellow. Eyes large and prominent. Ocelli large, below upper edge of eyes. Length of antennae 8 mm.

Length of thorax, 8 mm.; width, 9 mm. Pubescence yellow above, on sides and beneath. A rounded patch of black between the wings.

Wings subhyaline, smoky along the veins; veins brown. Expanse 44 mm.

Legs dark brown with black pubescence. Tarsi paler.

Length of abdomen 13 mm. Width, 9 mm. First two segments yellow above. Remainder of abdomen black.

The males of this species resemble those of pennsylvanicus but may be distinguished on account of having the third abdominal segment black, while in pennsylvanicus it is yellow.

The foregoing descriptions are based upon those given by the authors referred to in the synonymical list, and also on my examinations and measurements of three specimens in the Collection of the Illinois State Laboratory of Natural History:--one worker taken at Cobden, Ill., Sept. 12, 1882, and two males collected at Tamaroa, Ill., Sept. 22, 1882.

BOMBUS SEPARATUS Cress.

Synonymy

1863. *Bombus separatus* Cresson Proc. Ent. Soc. Plila. II, 165
 1864. *Bombus separatus* Packard Proc. Essex. Inst. IV, 114
 1887. *Bombus separatus* Cresson Trans. Am. Ent. Soc. Suppl. Vol. p. 308
 1902. *Bombus separatus* Titus Can. Ent. XXXIV, 37
 1903. *Bombias separatus* Robertson Trans. Am. Ent. Soc. XXIX, 176

QUEEN.

Average length, 22 mm.

Length of head in front, 7 mm.; width, including the eyes, 6 mm. Pubescence black, mixed with yellow on vertex and around the insertion of the antennae. Ocelli large, below upper edge of eyes. Eyes narrow. Length of antennae, 8 mm.

Length of thorax 10 mm. Width, 10 mm. Thorax yellow above and on the sides, with sometimes a few black hairs on the disk.

Wings smoky; hyaline within the cells; nervures brown.

Expanse 44 mm.

Legs dark brown with black pubescence; some specimens have the femora clothed beneath with yellow hairs.

Length of abdomen 12 mm; width 11 mm. First segment yellow. Second segment tawny yellow on basal middle.

WORKER.

Colored the same as the queen except that the basal middle of the second segment is brown instead of yellow, and the yellow

hairs on the head are more conspicuous.

The average lengths of the workers are as follows:

Foragers, 20 mm.; medium sized, 15 mm.; smallest, 12 mm.

MALE.

Length 18--20 mm.

Length of head in front 5 mm.; width, including the eyes, 5 mm. Pubescence on vertex and on front between the eyes yellow. Eyes prominent. Ocelli large, below upper edge of eyes. Length of antennae 7 mm.

Length of thorax 7 mm; width, 8 mm. Pubescence of thorax yellow above, beneath and on the sides. More or less black on the disk.

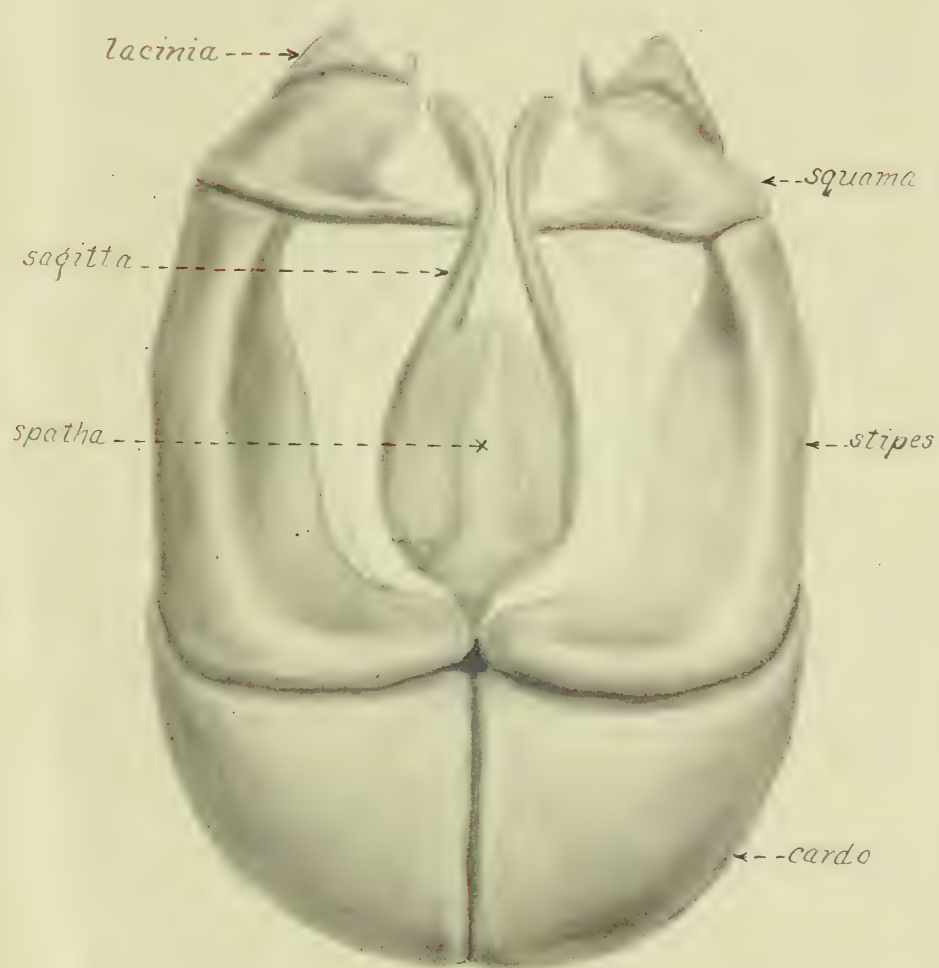
Wings subhyaline, nervures brown. Expanse 36 mm.

Legs dark brown to black. Pubescence black except on lower sides of femora which have long yellow hairs.

Length of abdomen 10--11 mm.; width, 7 mm. First segment tawny yellow above. Second segment tawny yellow or brownish on basal middle. Remainder of segments black.

Data of Material Studied

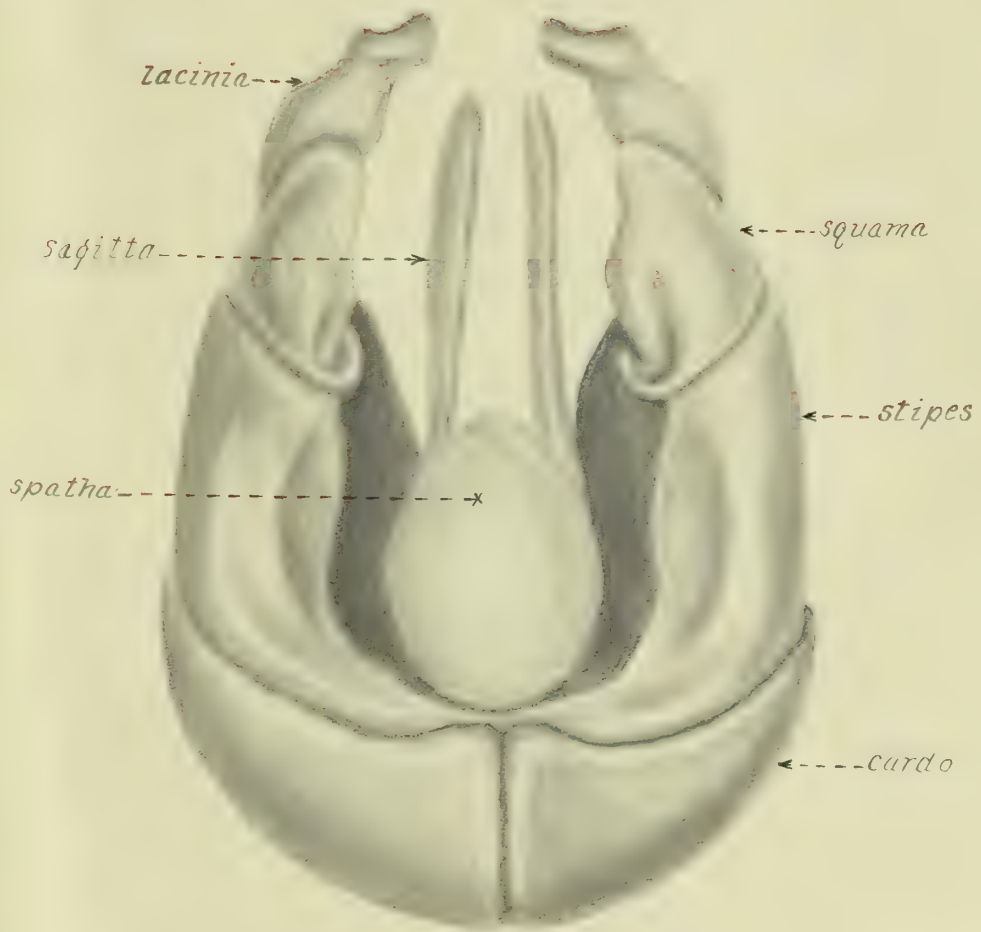
Date	Caste	Habitat	Locality	Collection	Remarks
Apr. 18, '91	1 queen	Woods	Urbana, Ill.	Lab. Nat. Hist.	C. A. Hart, Coll.
May 14, '92	1 queen	----	Algonquin, Ill.	Nason	
June 26, '07	1 queen	In orchard	Urbana, Ill.	Ent. Dept.	A. A. Hummel, Coll.
July 13, '87	1 worker	On sweet clover	Urbana, Ill.	Lab. Nat. Hist.	C. A. Hart, Coll.
July 13, '03	1 worker	On red clover	Urbana, Ill.	Ent. Dept.	Dr. Folsom, Coll.
July 15, '03	1 worker	On red clover	" "	" "	" "
July 21, '94	1 worker	On sweet clover	Algonquin, Ill.	Nason	
July 21, '96	1 worker	On herbage	" "	" "	
July 31, '89	1 male	----	Champaign, Ill.	Lab. Nat. Hist.	Marten, Coll.
July, '87	1 worker	----	Urbana, Ill.	Lab. Nat. Hist.	
Aug. 16, '89	1 male	----	Champaign, Ill.	" "	Marten, Coll.
Aug. 20, '85	1 male	On thistle	" "	" "	
Sept. 4, '89	1 male	----	Urbana, Ill.	" "	Marten, Coll.
-----	5 queens	----	----	Bolter	----
-----	2 workers	----	----	" "	----
-----	3 males	----	----	" "	----
-----	7 queens	----	Algonquin, Ill.	Nason	----
-----	8 workers	----	" "	" "	----
-----	4 males	----	" "	" "	----



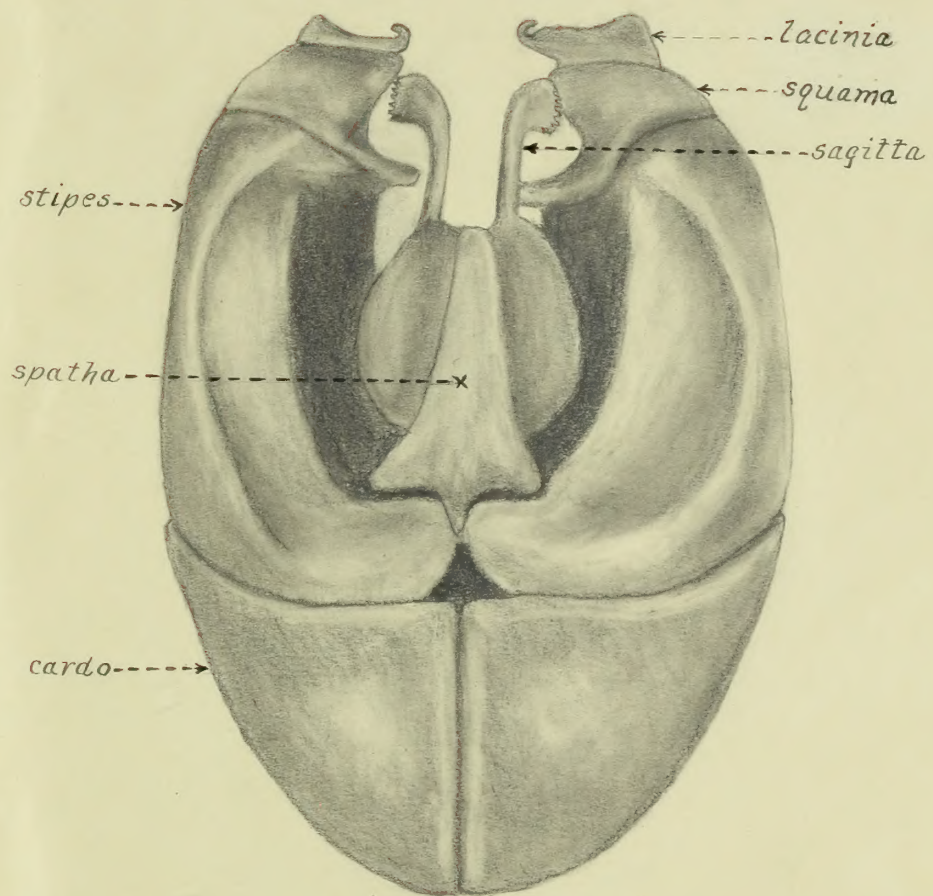
Bombus americanorum

Genitalia of ♂

X 30.



Bombus pennsylvanicus
Genitalia of ♂
X 30



Bombus fervidus

Genitalia of ♂

X 30





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